Using remote sensing and Earth system models to improve air quality and public health in megacities

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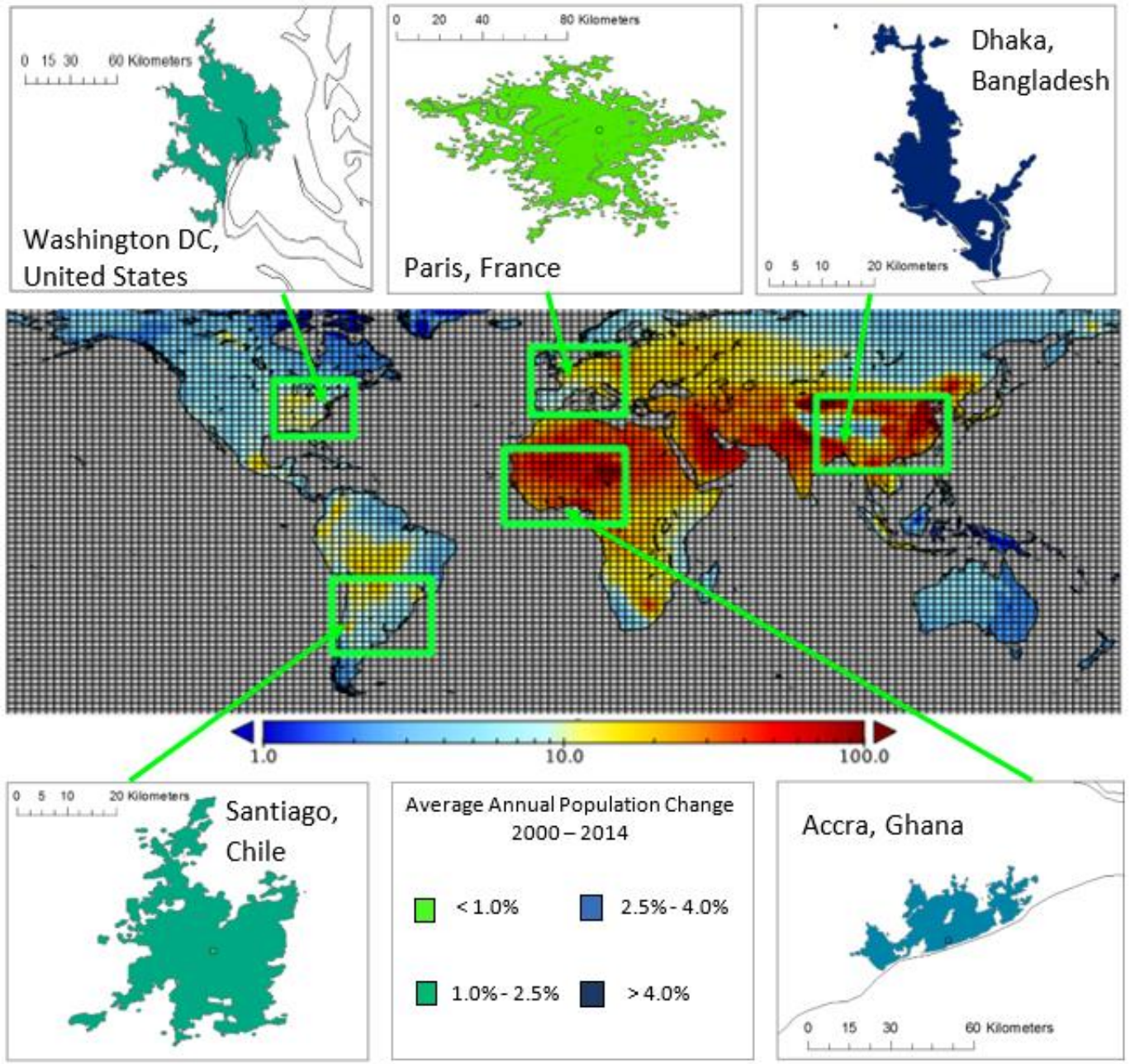
Presented by: Patrick Kinney, Boston University School of Public Health

NASA Health and Air Quality meeting
Rapid City, SD
September 10, 2019



Project overview

- Overall objective:
  - Meet the needs of the U.S. and international organizations to quantitatively assess air pollution health impacts and mitigation benefits in cities,
  - leverage the global coverage and fine spatial resolution from remote sensing, combined with Earth systems models and in situ measurements, to provide useful tools and information for urban decision makers.
- Specific objectives:
  - Improve and verify estimates of urban $PM_{2.5}$, O_3, and NO_2 concentrations and NOx and SOx emissions using data from MODIS, MISR, CALIPSO, OMI (as well as TROPOMI, eventually), and GEOS-Chem for five pilot cities* that are pursuing improved air quality management and serve as models for other cities;
  - Estimate 15-year trends in $PM_{2.5}$, O_3, and NO_2 exposures and associated mortality burdens at 0.01° resolution in all five cities;
  - Expand the national-scale tool (LEAP-IBC) used by the Climate and Clean Air Coalition to estimate health benefits of mitigation policies at the urban scale;
  - In partnership with the U.S. EPA, CCAC, and local officials, apply the new Urban LEAP-IBC tool to assess health benefits of air quality policy options in three global cities – Accra, Santiago, TBN.
- *Geographic Scope: Global (5 pilot cities – Washington DC, Paris, Accra, Santiago, fifth TBN)

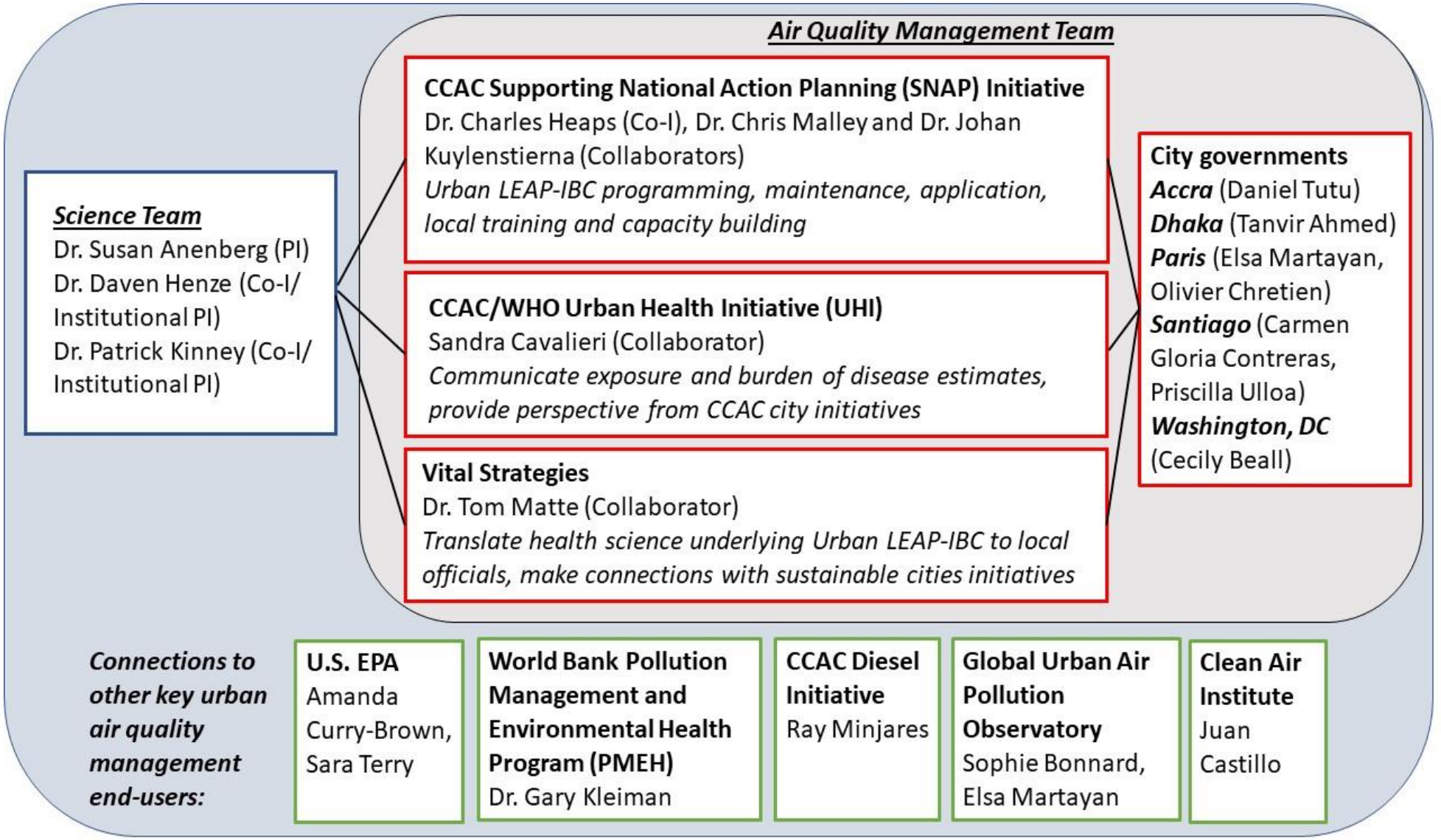
Team organization

Key stakeholders:

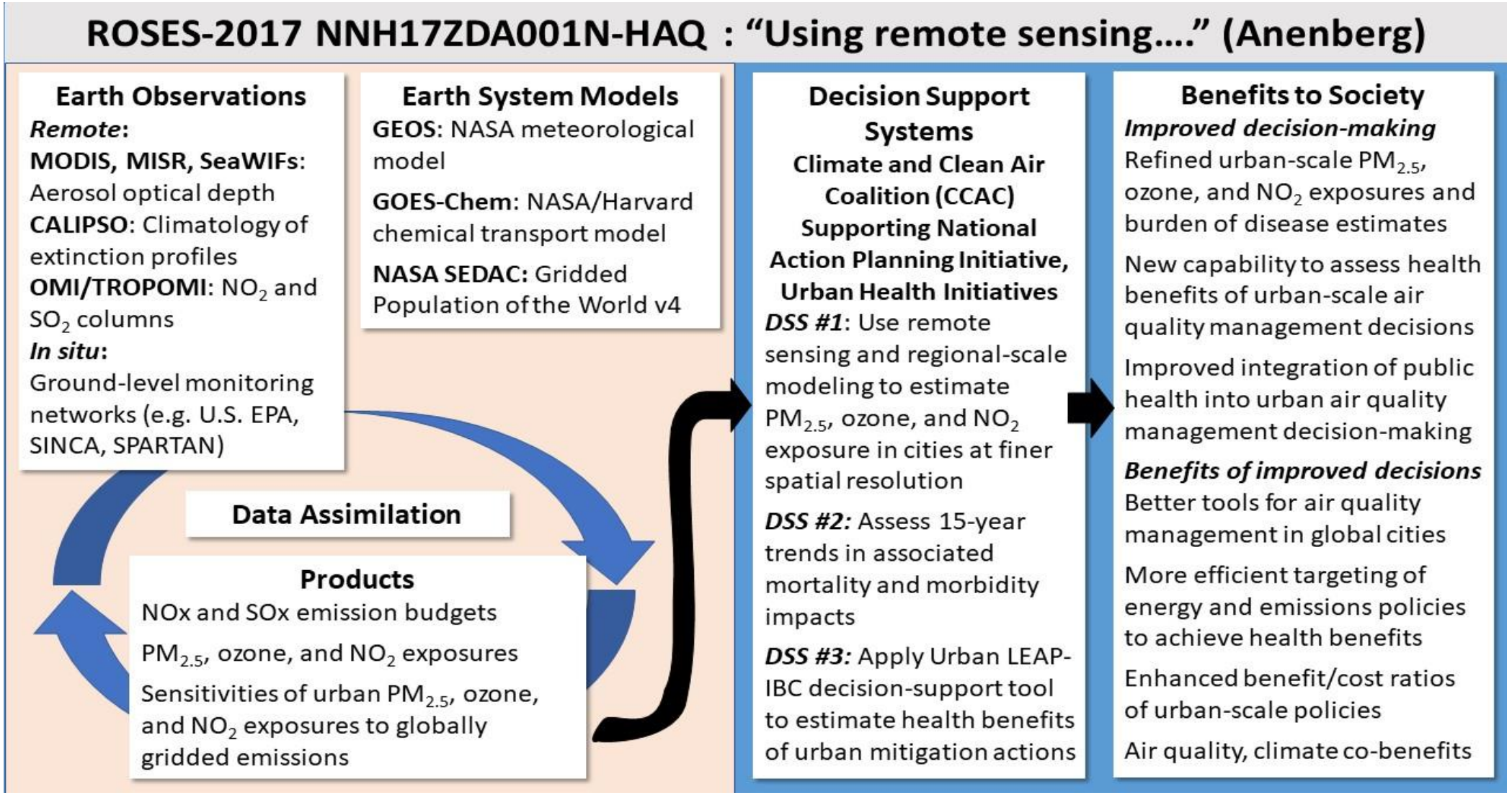
CCAC
CLIMATE AND CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

Vital Strategies

SEI STOCKHOLM ENVIRONMENT INSTITUTE

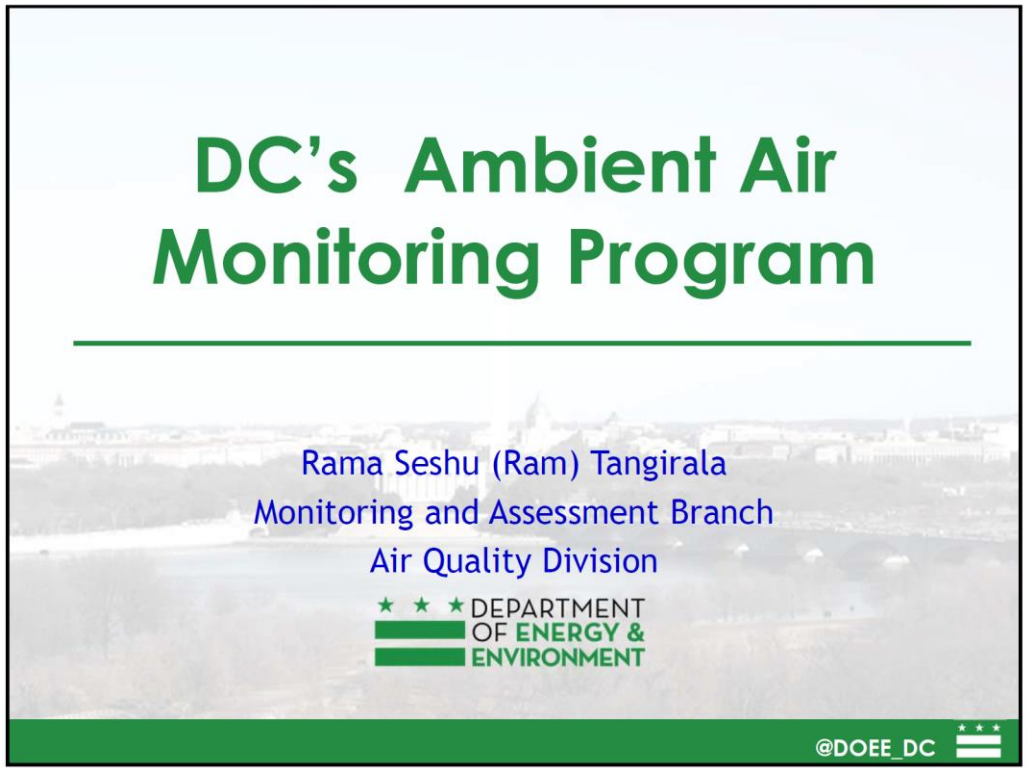


Earth observations and societal benefits



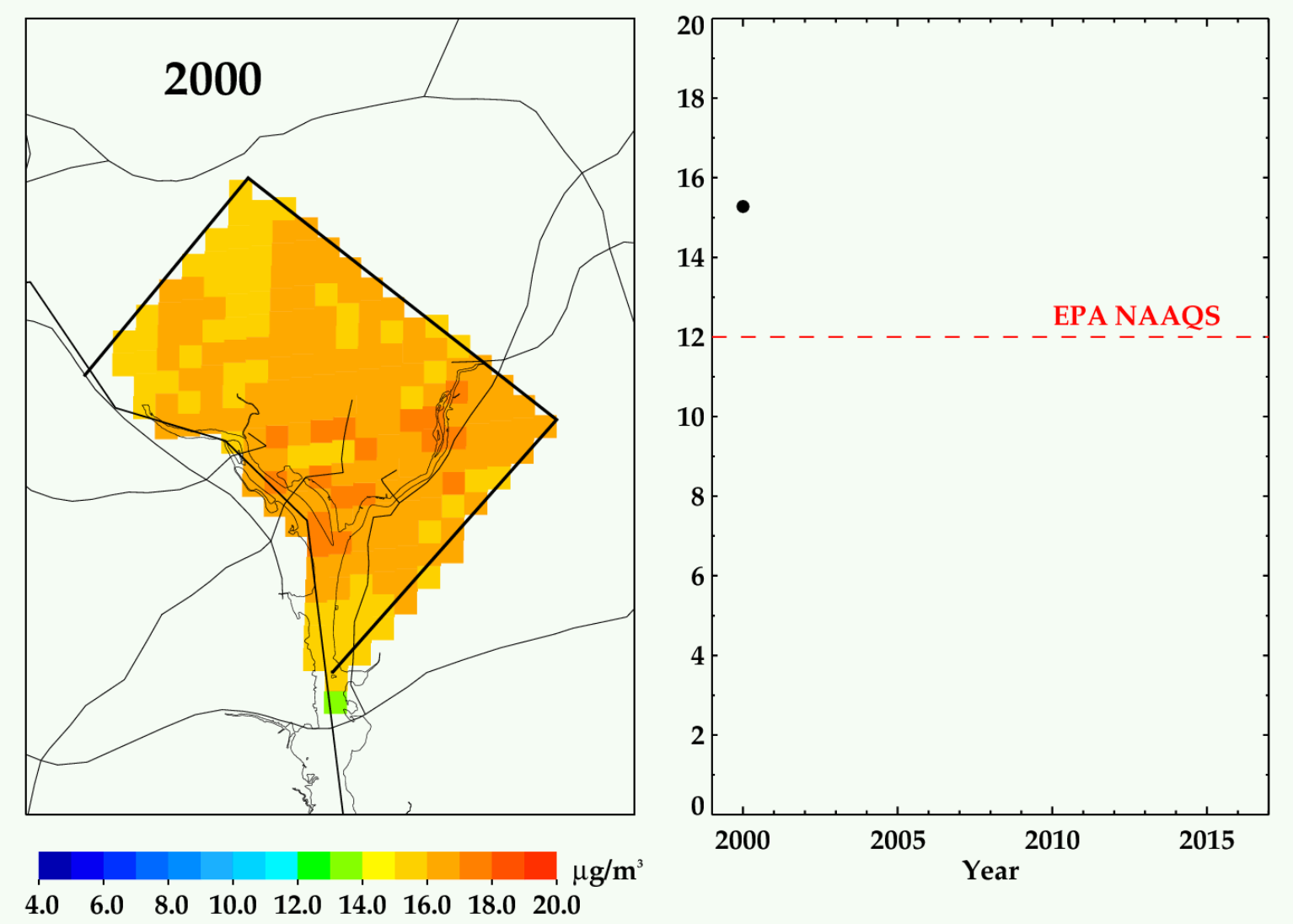
Stakeholder engagement

- Holding lively quarterly telecons with Climate and Clean Air Coalition leads, Stockholm Environment Institute, and Vital Strategies
- Stakeholder partners participated in May 9, 2019, “Science to Action Roundtable to Advance Joint Air Pollution and Climate Change Mitigation in Cities Worldwide” at GWU
- City governments
  - Hosted meeting with the DC Department of Health and Department of Energy and Environment at GWU on June 6, 2019, to discuss the project, share some early modeling, and hear their priority questions that they would like us to work on.
  - Prepared and submitted IRB application for fine scale DC health data.
  - Received health data at district level within Santiago.
  - In discussions with Paris health dept.



Presentation from DC Department of Energy and Environment at GWU on June 6, 2019

Initial results: PM2.5 in Washington, DC

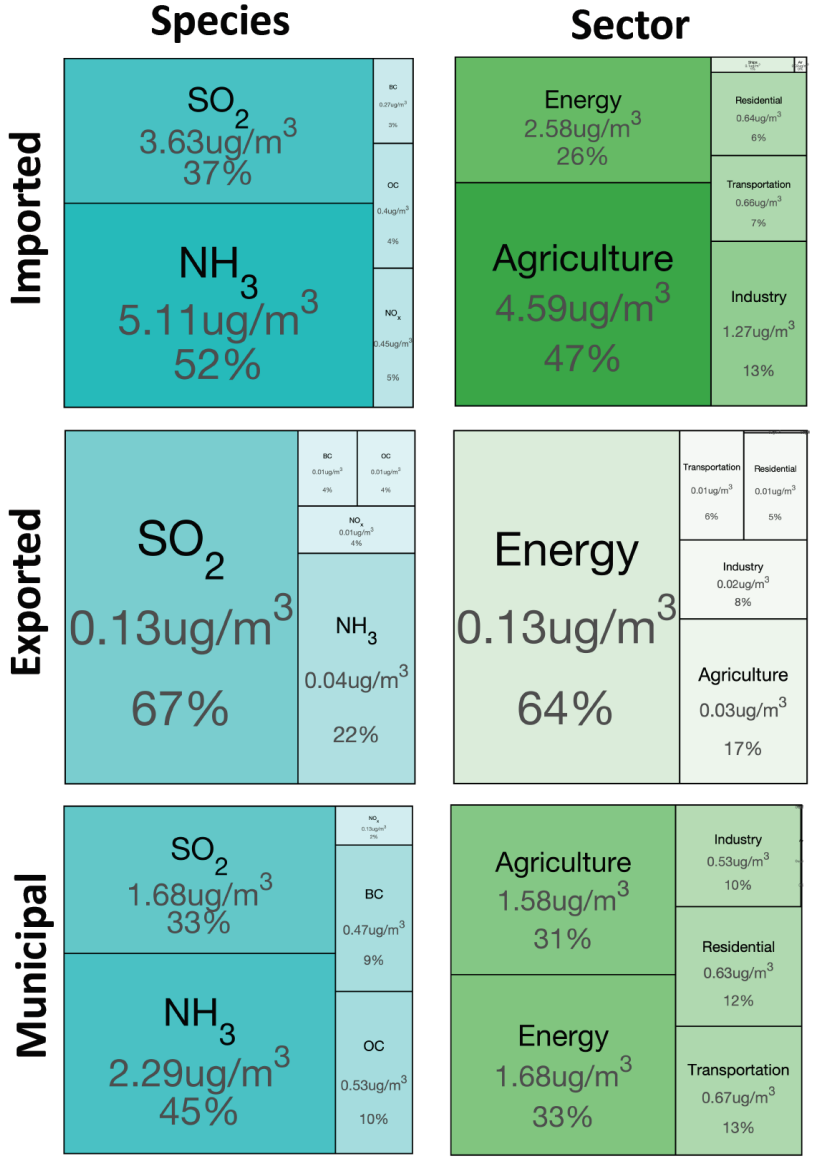


- Comparing several different satellite-based PM2.5 datasets for DC
  - Dalhousie
  - SEARCH
  - Harvard
- Developing satellite maps of NO2 and AOD for 5 pilot cities
  - OMI and TROPOMI for NO2
  - MAIAC for AOD
- Run CAMx and GEOS-Chem Adjoint chemical transport models to simulate emission source contributions to PM2.5 and ozone

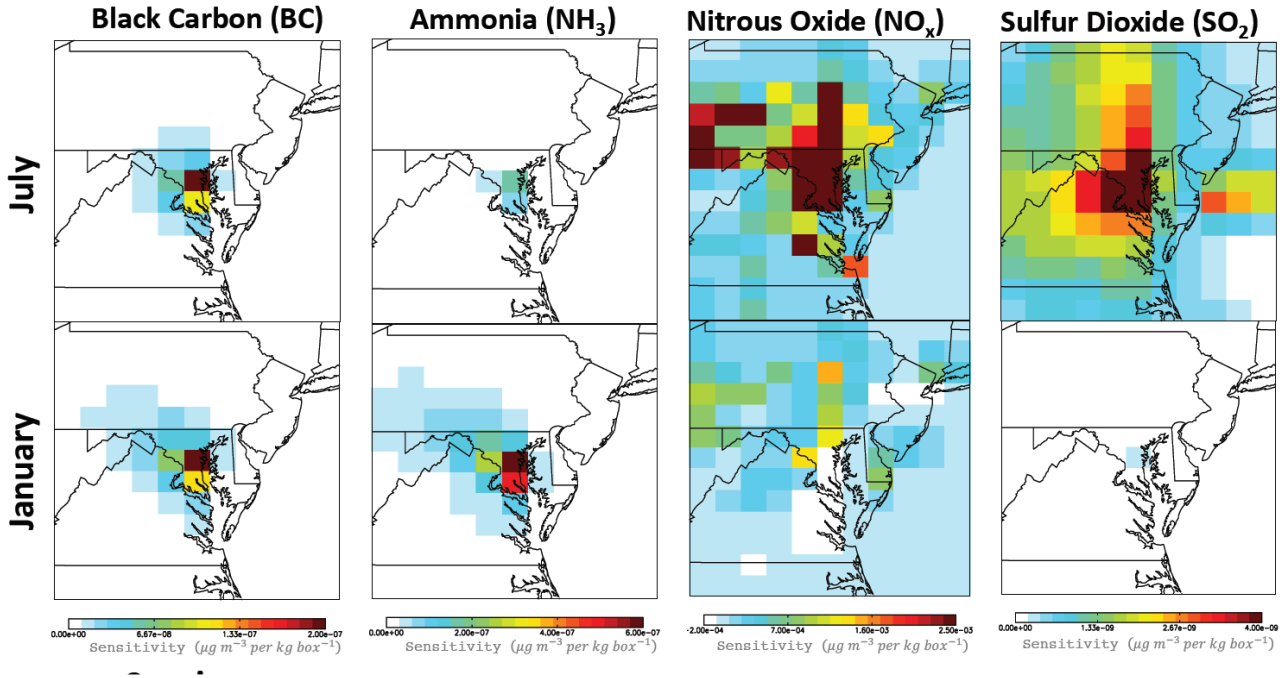
Figure prepared by Dan Goldberg (GWU); 1 km PM2.5 data provided by Harvard SPH

Initial results: Emission contributions to PM2.5 in DC from GEOS-Chem Adjoint simulations

Species and sector contributions to imported, exported, and municipal PM2.5



Sensitivity of PM2.5 in DC to emissions



Prepared by Omar Nawaz and Daven Henze (CU-Boulder)

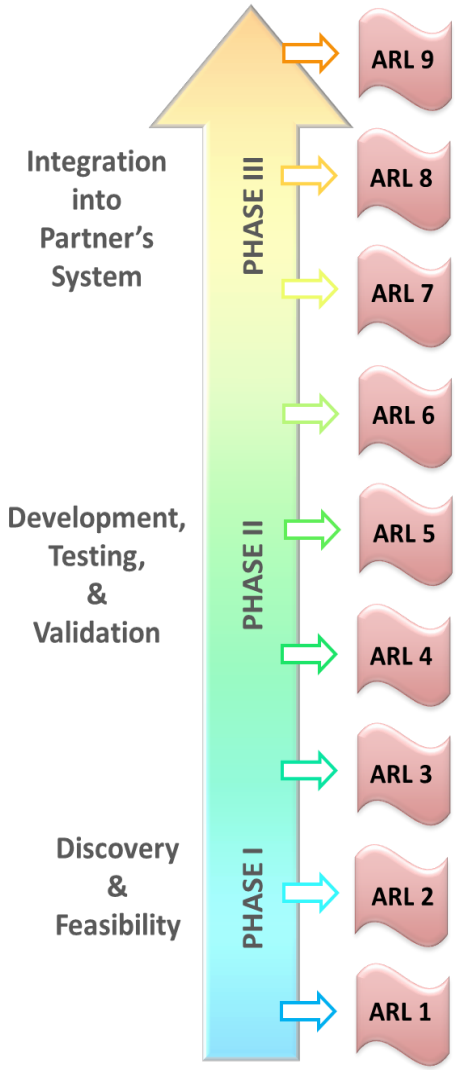
Schedule (Project initiation Nov 2018)

We are staying on schedule

- Preliminary results generated for PM2.5 concentrations and Adjoint sensitivities
- Data collection for health impact assessment in progress

Semester:	1	1	2	2	3	3	
Urban LEAP-IBC developed for $PM_{2.5}$ in three pilot cities [ARL 7]							
Refined $PM_{2.5}$ concentrations using satellite retrievals and modeling (CU-Boulder)	■						Ongoing
Refined city-specific $PM_{2.5}$ mortality and morbidity estimates (GWU)	■	■					Ongoing
Adjoint coefficients for city pop.-weighted $PM_{2.5}$ concentrations (CU-Boulder)		■					Ongoing
Adjoint coefficients incorporated into Urban LEAP-IBC (SEI)			■				
Urban LEAP-IBC workshop in Accra	■	■					
Urban LEAP-IBC expanded to NO_2 and O_3 [ARL 8]							
Refined NO_2 and O_3 concentrations using satellite retrievals and modeling (CU-Boulder)		■	■				Ongoing
Refined city-specific NO_2 and O_3 mortality and morbidity estimates (GWU)			■				Ongoing
Adjoint coefficients linking globally gridded emissions to population weighted NO_2 and O_3 concentrations (CU-Boulder)			■	■			
Urban LEAP-IBC workshop at CCAC meeting (Paris) and Santiago			■	■			
Application of Urban LEAP-IBC to evaluate policies [ARL 9]							
15-year trends in city-specific $PM_{2.5}$, NO_2, and O_3 health impacts (GWU)			■	■			
Satellite-constrained NOx/SOx emissions incorporated in Urban LEAP-IBC (SEI)				■	■		
Quantitative estimates of health benefits of air quality policy scenarios (GWU)					■	■	
Urban LEAP-IBC workshop at CCAC meeting (Paris) and Dhaka					■	■	
ARL	6		7	8		9	

Application Readiness Level



- Start-of-Project ARL = 6 *(November 2018)*
  - This project builds on past Applied Sciences support through AQAST and HAQAST and direct support for Co-I Henze from the CCAC through U.S. EPA.
  - The national-scale LEAP-IBC tool has already been used to inform decision-making activities for 12 CCAC member nations.
  - Urban LEAP-IBC development has begun for one city (Accra) through CCAC funding and to another (Nairobi) with SEI internal funding.
- Goal ARL = 9 (October 2021)
  - We expect to be at ARL 7 with development of Urban LEAP-IBC for PM2.5 in three pilot cities,
  - ARL 8 with expansion to NO2 and O3, and
  - ARL 9 with the application of Urban LEAP-IBC to evaluate air quality policies in three pilot cities (Accra, Santiago, and another city TBN).
- Current ARL = 6 *(August 2019)*
  - The project is currently at ARL 6 as the new scientific analysis for the project is still in early stages.
  - Urban LEAP-IBC development for Accra is in progress. GEOS-Chem Adjoint sensitivities for Washington DC have been generated and are now being evaluated. Satellite observations of NO2 and PM2.5 (from AOD) have been downloaded for each of the five cities (the four named plus Jakarta) and are being evaluated. Disease rates for Santiago, DC, and Paris are being downloaded and evaluated.

Project challenges and risks

- Technical challenges:
  - Some pilot cities do not have emissions data, health data, and/or epidemiological concentration-response functions
    - Solution: Will use national data where city-specific data do not exist

- Operational challenges:
  - PI on parental leave June-October 2019
    - Solution: Hired Dan Goldberg as Research Scientist at GWU who is helping to keep project moving forward
  - Air quality management team has not agreed on a fifth pilot city – narrowed to Jakarta or Hanoi
    - Solution: Science team will select one if no decision made by stakeholders, but still have time

- Political challenges:
  - Engaging city government staff is difficult due to staff turnover and changing political priorities
    - Potential solution: Rely on our stakeholders to maintain/build relationships with city government employees and communicate between them and the science team

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